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VARIATION IN RECENT MOLLUSCA.

By E. R. Sykes, B.A.

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Variation in Zoology consists of the differences seen in animals, and may be divided into two branches: the series under observation is called continuous, where we pass from one form to another by imperceptible gradations, or the term discontinuous is used, where there are marked gaps.

Too much stress cannot be laid upon the importance of the subject, and a true appreciation thereof is necessary both to the morphologist and the systematist, while to the student of evolution it is the foundation of his work. It is of special interest to the systematist, since, without some knowledge of it, he is unable to properly utilize the unit of his classification, a species; and, indeed, he is frequently in ignorance of what a species and its true limits may be. For instance, *Pisidium sinuatum*, Brgt., is only an ordinary species with a sinuous margin; *Calyptrea spirata* is said to be a variation of *C. Chinensis* which has taken its form owing to living in mud, where its sole attachment is to *Turritella*; *Ampullaria Brohardi* and *Voluta Brazieri* are probably only monstrosities; while those curious distortions found in *Planorbis* have had nearly a dozen unnecessary specific names. There is in the British Museum a specimen of *Nautilus* which, viewed from one side is *pompilius*, while if it be examined from the other side it appears to belong to *stenomphalus*.

Again, the student of evolution desires to know how far the forms seen to-day are constant, or in what manner they are affected by that ever-present law of Nature, variation, progressive or retrogressive, as it may be. It has been strongly urged that amongst the Achatinellidæ, for example, new species have been formed, and old ones have died out, even in recent years. Generations of molluscs succeed one another very quickly, and change of surroundings is liable to have a speedy effect. These changes are taking place very rapidly at the present day. In Saint Helena the bulk of the land fauna is extinct, owing to the destruction of the trees, and similar conditions threaten many other oceanic islands. In North America it has been noticed [1] that some of the woodland shells have been compelled to change their habits and live in the open country.

I would not suggest that every trifling variation be endowed with a separate name, since that course must prove the road to chaos, but

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[1] Billups: Nautilus, vol. xvi, p. 112.

well-marked variations, especially such as are found isolated from the normal form, are worthy, not only of being placed on record, but also of figuring in nomenclature.

The desirability of these variations being noticed in our literature is well illustrated by a reference to the specimen of *Fistulana* piercing *Mitra*, recently described in our *Proceedings*. This was treated by us all as a hitherto unknown occurrence, but it may be mentioned that there is a specimen of *Fistulana* in the British Museum, collected so long ago as the days of Belcher, which has pierced in precisely the same manner through a valve of one of the Veneridæ.

The uses of the variations seen are but little known; but as an illustration of the utility of spines it may be stated that François[1] noticed that *Murex fortispina* could open, and did, in fact, open the valves of *Arca* by means of the tooth-like process on the outer lip.

Variation is as well-marked and as striking a fact in Palæontology as in Recent Zoology, but owing to the vastness of the subject I have confined myself to-night to a very brief outline of some facts presented by recent molluscs, and a few suggestions made relative thereto, one or two points being specially dwelt on.

I have not attempted, as I had at first proposed, to give full references for every fact mentioned, or the following pages would have in the main borne the aspect of a bookseller's catalogue; it must, however, be taken that the work is, as such work must be, a compilation from the labours of others.[2]

Hybridism in the Mollusca seems to have been but little studied. It has been noticed (in captivity) in *Limnæa*. Hartman states[3] that in *Partula* hybrids are common amongst some species and rare in others, those observed being usually the offspring of proximate species. He suggests that as *Partula* is hermaphrodite they may produce fertile hybrids, and throws out the conjecture that it is possible that some forms of the genus may have so arisen. The occurrence is also said to have been observed between several Helices, *Rumina decollata* and *Helix*, *Pyramidula rotundata* and *Vitrea lucida*, *Clausilia papillaris* and *Pupa cinerea*, *Littorina rudis* and *L. obtusata*, *L. rudis* and *L. litorea*. Furtado[4] collected in the Azores ten specimens of *Vitrina*, and in every one the reproductive organs were lacking; from this and the appearance of the shell he suggested that they might be hybrids, and he cites similar suggestions which had been thrown out with regard to *Buliminus* and *Zonites* (*Hyalinia*) from those islands. In this connection we may also mention the statement[5] that the interbreeding of French and Algerian races of *Rumina decollata* is said to have produced a new variety with a dentiform callosity in the aperture.

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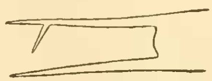
[1] Arch. Zool. Exper., vol. ix (1891), pp. 240–242.
[2] At the request of several members a number of references have now been added, but no attempt has been made to render them complete.
[3] Bull. Mus. Comp. Zool., vol. ix, p. 173.
[4] Ann. Nat. Hist., ser. v, vol. ix, p. 397.
[5] Gassies: Journ. Conchyl., vol. ii, p. 356.

Abundant instances of discontinuous variation are found in studying the animal. For example, double and even quadruple monstrosities are found in the embryo in *Limax* and *Planorbis*; double also in *Philine*.[1]

Deformation and variation of the eyes and tentacles are by no means uncommon. The tentacle and eye can be renewed, but this can only be done if the supra-pharyngeal ganglion is uninjured.[2] *Patella vulgata* has been seen with two tentacles and two eyes on the left side, the right being normal; *Nassa* with two eyes on the right-hand tentacle; *Littorina* and *Clausilia bidens* with a similar character; while in *Pecten* one eye has been observed imperfectly divided into two, the division being at right angles to the mantle-edge. Duplication of the extremity of the tentacle has been observed in *Helix lapicida*, the nerve being equally divided, and bifid tentacles have also been observed in *Nacella ænea*, *Littorina*, *Limnæa*, *Ancylus*, *Physa*, and *Helix*. *Triopa claviger*, again, has been examined with the upper tentacles, or rhinophores, abnormal owing to the right-hand one being divided into three branches. A specimen of *Subemarginula* was found bearing upon



Cyclophorus, with bifurcate tentacle. (Sketch by Capt. A. J. Peile.)

each of the eye-projections two eyes in place of one, the tentacles being dwarfed. Adherent tentacles, attached throughout except for a slight cleft at the end, are noted in *Helix hispida*, and a somewhat similar case has been observed in *Limax agrestis*. *Limax lævis* has been observed without any tentacles at all. Perhaps, however, the most interesting case is that recorded by Moquin-Tandon, namely, a double-headed *Limnæa auricularia*, one head being a third larger than the other. In the larger head the tentacles, eyes, mouth, etc., were normal, but in the smaller the left tentacle was dwarfed and had no eye.

Like the other organs, the radula is liable to vary.[3] It has been shown that there is often an increase in the number and size of teeth and some variation in their form as the animal becomes older (*Hyalinia* and *Limax*). Age, however, affects many anatomical features as well as conchological; for example, the number of plicæ in the gills of Pelecypods is greater in the adult than in the young. Deformation of the teeth of the middle row of the radula has been noticed in *Helix*

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[1] Lacaze Duthiers: Arch. Zool. Exper., vol. iv, p. 482.

[2] Cf. Fischer: Journ. Conchyl., 1864, p. 89; 1856, p. 230; 1888, p. 131. Forbes & Hanley: Brit. Moll., vol. iv, p. 288. Jeffreys: Brit. Conch., vol. iv, p. 350. Van den Broeck: Ann. Soc. Mal. Belg., vol. v, p. 29. Roberts: Sci. Gossip, vol. xxii, p. 259. Pelseneer: Res. Voy. Belgica, Mollusca.

[3] See Binney: Bull. Mus. Comp. Zool., vol. v, p. 337. Jickeli: Nachrbl. Deutsch. Malak. Ges., 1873, p. 68. Sterki: tom. cit., p. 172. Esmark: Mag. Naturw., vol. xxvii, p. 92.

desertorum, and malformed teeth have been seen in *Leptaxis undata*, Lowe, whilst considerable variation has been noticed in *Aplysia*. Bateson[1] has collected several observations on the radula of *Buccinum*, showing that on the median plate the denticles may be as low as three in number, or as high as nine, whilst the laterals may have from three to five denticles, these latter again being sometimes unequal on both sides of the radula, i.e. four on one side and three on the other.

Of the generative organs, cases have been noticed[2] where the male generative organ, which should have existed, was entirely wanting (*Arion hortensis*, *Limax lævis*), and in *Pupa muscorum* a specimen has been seen[3] where the male organ was rudimentary and the female well developed. Whitfield[4] noticed that the progeny of *Limnæa megasoma*, produced during confinement, exhibited changes in the soft parts, particularly diminution and disappearance of the hermaphrodite gland, which in the third generation was entirely lacking, while the female organ retained vitality, and he suggests that the atrophy of this caused the slenderer form which he noticed the earlier whorls took. The result has been also attributed to the want of sufficient and appropriate food. A case of the closing of the genital opening has been noticed[5] in *Helix aspersa*, which has been attributed to a lack of full development. The generative apparatus of *Helix pomatia* has in one specimen been found to be divided into three entirely separate groups, and other interesting variations have been noticed.[6] Parasitic castration in *Helix aspersa* has also been recorded.[7]

Mention should be made also of the curious specimen of *Helix nemoralis*, L., recorded by Fischer,[8] which was furnished on the back of the foot with a fleshy cylindrical appendage, situated, when crawling, just behind the shell.

In the Pelecypods some variation has been observed in the position of the adductor muscles. Downing[9] found in *Anodonta* that in specimens of varying ages the distance of the muscles from the umbo varied considerably in relation to their distance from the shell-margin, and suggested that perhaps the muscles moved less rapidly than the shell grew. The anterior muscle was found to move more rapidly than the posterior.

A curious specimen of *Mytilus edulis* was examined by Vayssière,[10] in which the valves gaped at the far end and the mantle was largely developed, filling the cavity.

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1 "Materials for the Study of Variation," p. 262.
2 Collinge, Journ. Malac., vol. xi, p. 15; and see S.B. Ges. Leipzig, 1883, p. 74.
3 Wiegmann: Jahrb. Malak. Ges., vol. v, p. 159.
4 Bull. Amer. Mus., vol. i, pp. 29–37; cf. Proc. Boston Soc., vol. xx, and Dall, Bull. Phil. Soc. Washington, vol. iii, p. 75.
5 Maugenot: Bull. Soc. Zool. France, vol. viii, p. 130.
6 Bietrix: Bull. Soc. Philom., ser. VII, vol. x, p. 74. Semper: Reisen Arch. Phil., vol. v, p. 247.
7 Garnault: Bull. Sci. Fr. Belg., vol. xx, p. 137.
8 Journ. Conchyl., vol. xxv, pp. 211–212, pl. iv, fig. 4.
9 Amer. Nat., vol. xxxvi, pp. 395–400.
10 Journ. Conchyl., ser. III, vol. xxxix, p. 213.

Tellina incarnata has been observed with only one siphon and no labial palps.

Bloomer[1] found that in *Anodonta* the animal is able to repair even extensive damage to the mantle-lobes, but is not able to make good injuries to the gills, and that the mollusc can live and thrive with aborted respiratory organs.

Amongst Cephalopods, we may refer to a specimen of *Eledone cirrosa*, examined by Appellöf,[2] in which not only was the third left arm developed as hectocotylus as usual, but also the third right arm.

The operculum, we are all aware, may be present or absent in members of the same group, but it does not seem to be so generally known that it may be present or absent in the same species. Of a series of *Volutharpa ampullacea* examined by Dr. Dall, the majority were without opercula or any trace of the pad-like area from which the operculum is secreted, some had traces of this region, and others well-developed opercula. The bioperculate *Buccinum undatum* are well known, and a specimen has recently been taken off Unst.[3] Clark found that every specimen of *Trochus lineatus* from one spot near Exmouth had distorted opercula, a fact which Jeffreys referred to some disease of the opercular lobe.

The epiphragm formed by many shells when æstivating deserves more consideration than it has received. It would be interesting to know how far the same form is constant in a genus, and what the explanation of those curious structures noticed in the specimens of *Thaumastus*, figured recently[4] in our *Proceedings* by Mr. Smith, may be.

There seems to be but little relationship between the colour of the animal and that of the shell. Many colours are seen in the animals, Camerano[5] stating that black is rare; brown, grey, yellow, white, and red, common; violet, fairly common; blue, not rare; while green is infrequent. His observations also led him to the belief that animals with strong shells were more highly coloured than those with fragile shells. All parasitic molluscs appear to be white. Age seems to have some effect, as also food, while conditions of temperature have been observed to be correlated with slug-coloration. In Germany it has been noticed that warmth either inhibits black or causes it to disappear, while exercising an opposite effect on red. *Limax arborum* has been noticed to be spotted with black on the plains and of normal coloration on the hills.[6] In this connection a very interesting paper by Simroth[7] should be studied. Collinge,[8] studying the colour of the foot-fringe of *Arion empiricorum*, found extraordinary variation, which

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[1] Journ. Malac., vol. vii, p. 138.
[2] Bergens Mus. Aarbog, 1893, p. 14.
[3] Standen: Journ. Conch., vol. xi, p. 62.
[4] *Ante*, p. 3.
[5] Mem. Acc. Torino, vol. xxxvi, pp. 348–349.
[6] Cockerell: Zoologist, ser. III, vol. x, p. 341.
[7] Nachrbl. Malak. Ges., xviii, pp. 65–80.
[8] Journ. Malac., x, p. 19.

in captivity proved inconstant. Temporary surroundings, again, affect the colour of slugs, a result which has been said to be due to slime secretion. Nudibranchs will vary with their habitat, and their brilliant colouring will become somewhat faded in captivity.

Planorbis corneus has been observed with a flesh-coloured or pink animal.

The shell is, as is well known, usually more brightly coloured in land molluscs, in warmer climates; this is also noticeable amongst marine shells, Arctic species, as also those from the deep sea, being usually inconspicuous in colour. In dry and arid regions the shell is often white and thick, the thickness hindering evaporation, and the whiteness being a protection from the sun's heat. Variation of food will alter the colour of the shell, and a curious brown-coloured race of *Helix hortensis* has been found[1] near tanneries, while yellowish forms of *H. nemoralis* are said[2] to prevail in dried grass, red or reddish-brown being most common at the edge of woods. In America it is stated[3] that the colour of *Pyramidula alternata*, which lives in decaying wood, varies with the kind of tree in which it is found, and resembles that of the surroundings; this latter consideration, however, is foreign to my purpose at the moment. Similarly a damp season produces an effect.

Mr. Brindley[4] recently found that of 639 *H. arbustorum* 465 were adult, and of these 15 were without any trace of banding, while of 261 *H. nemoralis* 21 were bandless, and these were mostly brownish in colour.

Rays of colour in the Unionidæ are most commonly found[5] in specimens from running, not still water; while on the point of colour rays or bands in general I may remark that they are exceedingly inconstant, and may arise or cease suddenly.

The entire absence of any colouring in shells which normally are coloured is by no means rare. This is not, in general, correlated with any apparent change in the animal, and cases of albinism in the animal are very scarce. *Vivipara vivipara* has been seen[6] in an isolated example to be absolutely lacking in black pigment, even in the eyes, and the same has been recorded in *Agriolimax*.

Shells may be white, or transparent and colourless. The causes may be various; food, a damp season, or some inherent defect in the secreting power of the animal have all been stated to cause it, and it may occur either in isolated specimens or in whole colonies. In France albinism is said to occur more in the north and in mountainous regions. White *Helix incarnata* are said to have had white descendants, but in other cases normal young have been bred. Gredler suggested that the white forms were perhaps hereditary, but somewhat morbid, and he

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[1] Martens: Nachrbl. Deutsch. Malak. Ges., 1872, p. 44.
[2] Winkworth: Essex Nat., vol. xiii, p. 256.
[3] Ormsbee: Nautilus, vol. x, p. 64.
[4] Mollusca in Nat. Hist. Cambridgeshire, p. 122.
[5] Jordan: Biol. Centralbl., vol. i, p. 392.
[6] Simroth: Zool. Anz., vol. ix, p. 403.

stated that the albinos were often smaller than the coloured specimens, and found near the boundary of distribution. *Limnæa* and similar genera are sometimes found with white colour-bands.[1]

In marine shells but little has been recorded, but I may perhaps refer[2] to a curious spot on Portland where, in a marine pond a few yards across, the fauna consisted of two white species, two species of which white varieties occurred without the normal coloured form, and two species where the normal form occurred with white varieties.

Ere passing from this branch of the subject, I would call your attention to a paper by Cooke[3] in which he discusses the variation of *Achatinella multizonata* from a geographical standpoint. He states that while the actual specific distribution extends over some little area certain groups of colour-varieties are confined to certain portions of the range, and he concludes that isolation pays a greater part than environment.

Erosion has been noticed in many species; specimens of fresh-water bivalves are often eroded near the beaks, where the periostracum is thinnest, and Gastropods often show similar signs, generally on the earlier whorls. It has been attributed[4] to emission of carbonic acid gas by plants, and also to a deficiency of calcium carbonate in the water; whilst in confinement, *Limnæa*, *Bithynia*, and *Planorbis* have been noticed[5] to become eroded and of carious appearance, and the eroded spots have been seen to be occupied by *Micrococcus*. It has been stated that in a river in North America all the shells below the spot where a pollution by alkaline wastes entered the stream were eroded, while those above were not. In marine shells it has been said[6] to be due to boring algæ; and many specimens have been noticed where the animal has thickened its shell internally for protection.

Decollation, the earlier whorls having been broken off and the cavity closed by a septum, is a normal occurrence in a number of Gastropods, e.g., *Truncatella*, some *Cylindrella*, etc. Many long-spired shells do not use the upper whorls, and this part loses vitality, becomes brittle, and breaks off. It may, however, occur abnormally owing to an accident to the spire. In confinement a scalariform *Helix aspersa* has been noticed,[7] which on more than one occasion formed internal septa, the upper portion breaking off.

It must be remembered that Mollusca have the power of absorbing the upper whorls, so as to make room for themselves, and further, that they can secrete shelly matter to repair a hole broken in the shell. *Helix pomatia* can repair the upper whorls; and, in captivity, *Limnæa elodes* has been observed to repair a hole in the shell in six weeks.

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1 Overton: Journ. Malac., ix, p. 64.
2 Journ. Conch., vol. vi, p. 166.
3 Pap. Bernice P. B. Mus., vol. ii, pp. 65–76.
4 Beauchamp: Conch. Exch., vol. i, p. 49. Shrubsole: Journ. Conch., vol. v, p. 66.
5 Noll: Zool. Garten, vol. xxiii, p. 157.
6 Hensman: Irish Nat., vol. iv, p. 137.
7 Lataste: Journ. Conchyl., vol. xxiv, p. 242.

External sculpture in the Gastropods is very variable, and the shell may be furnished within the mouth either with ridges or tubercles; the columella being often provided with accessory plates or folds: the wonderful armature of the Helicoids, Cylindrellids, etc., at once comes to mind. Shells such as *Crepidula* and *Anomia* will form ridges, tubercles, etc., to match their site. While in many cases the internal armature is specifically constant, in others it shows considerable variation, such as the presence or absence of teeth in the Pupidæ. The crenulations on the margin in *Astarte*, again, have been recently[1] alleged to be sex characters, those with a crenulated margin being said to be female, those with a smooth edge male; and the point is one of considerable importance since these characters have been used for the separation of species. Dr. Dall states that in Alaska *Littorina*, where exposed to the full power of the surf, becomes shorter in the spire, the ridges become rounded nodules, and the axis of the shell broad and thick; an illustration of the principle that sculpture is largely due to the surroundings.

Our common *Purpura lapillus*, again, varies greatly in sculpture, some showing well-marked foliations in addition to the usual spirals, and it may be remarked that those in which the foliations were most noteworthy come from an old oyster bed in Rhoscollyn Bay, where lime would be abundant.

The variation of the ribbing in *Cardium* has been noticed[2] by Baker, and, on comparing three species, he found that they differed in the amount of variation, *C. magnificum* being the least variable, *C. muricatum* the most variable, while another form was intermediate. *Pecten* also has been carefully studied by Davenport,[3] who found that the same species was more variable in some places than in others: he also states that the right valve has half a groove more than the left or upper one, and that the variability of the right valve is less than that of the left.

The Gräfin von Linden[4] found on examination that the primary stage in sculpture was, in the forms seen, usually a thickening of the lines of growth to form transverse ridges; then, firstly, transverse and, secondly, longitudinal, tubercles appear, and finally longitudinal bands.

Beecher,[5] studying spines, found that they only appear after the earlier stages, and he suggested that they may be formed by a special stimulus given to the secreting organs. Sometimes they are due to radiating lines being broken, and differentiated into spines, as in *Lima*. In such forms as the Murices and Spondyli he states that they are often formed by local repetition close to or on an ordinary spine. Further, he calls attention to the fact that in some of the Pliocene

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[1] Ostroumoff: Zool. Anz., vol. xxiii, p. 499.

[2] Amer. Nat., vol. xxxvii, p. 481; cf. Dall, Tert. Fauna Florida, pt. v.

[3] Proc. Amer. Ac., vol. xxxix, p. 123; Amer. Nat., vol. xxxiv, p. 863; Science, vol. xv, p. 531; Journ. Exper. Zool., vol. i, p. 607, etc.

[4] Zeitsch. Wiss. Zool., vol. lxi, pp. 261–317.

[5] Amer. Journ. Sci., ser. IV, vol. vi, pp. 1–20, etc.

beds the species in the lowest beds are smooth, higher up they become angular and carinated, and finally they are sub-spinose.

Sculpture, as is well known, is due to increased secretion at certain points, but how and why are these points determined?

In this connection two very interesting papers dealing with the Gastropods merit consideration. Dall[1] was led to consider the folds on the columella in the Volutidæ, and he pointed out that in the molluscs with folds on the columella the adductor muscle was situated more deeply in the shell than in those in which the folds were absent. Further, he stated that when the mantle-cone was withdrawn within the shell, it must wrinkle longitudinally, and the more deeply-seated the adductor muscle was, the stronger would be the wrinkles, the deeper wrinkles coming on the columellar side, and the more numerous, smaller ones being opposite to the pillar. From this he was led to consider that the folds on the columella and the liræ or denticles within the mouth were formed by the repeated dragging in and out of the shell-secreting surface of the mantle, the folds or liræ forming in the wrinkles. This explains the folds in some forms of *Cypræa*, which are seen only in the adult shell, since in the young the mouth is more widely open, and the mantle not so wrinkled. It would be of interest to know how far the remarkable internal armature in *Plectopylis*, formed only at certain intervals in the shell, is due to such wrinkling of the mantle at rest periods, and whether their constancy in form is due to the mantle being folded naturally in a permanently similar manner, conformably to the internal organization of the animal.

A further development of the same theory was made by Stearns[2] in a paper on the remarkable series of variations of *Paludestrina protea*, Gould, in which he attributes spiral sculpture on the surface of the shell to puckering of the mantle-edge, while transverse sculpture he points out may be formed owing to a short period of rest when the edge of the lip is receiving the bulk of the secretions.

For further interesting details the student should consult these two papers.

There are giants and dwarfs in molluscs as in all other animals. *Buccinum undatum*, L., for example, may measure as much as 6½ inches in length, while an apparently adult specimen in my collection reaches only 1½ inches. Size may depend upon surroundings, and those at the extreme limit of distribution of the species are often stunted in growth. *Neritina virginea* is dwarfed in very dense water, as also in fresh-water streams in Jamaica, from which the deduction has been drawn that while the animal can adapt itself the full development will only be reached if the surroundings be favourable. Similarly, Bateson[3] has given an account of variation in form, etc., occurring in *Cardium*, where the water was very saline. In Guernsey there are two distinct races of *Ocinebra aciculata*, varying in size and colour, one

[1] "Tertiary Fauna of Florida," pt. i, pp. 58 et seq.; Amer. Nat., 1894, pp. 909–914.
[2] Proc. U.S. Mus., vol. xxiv, pp. 271–299.
[3] Phil. Trans., 1889 B, pp. 297–330.

being found on the shore and the other dredged. *Helcion pellucidum*, when found on the leaves of *Laminaria* is thin, with bluish rays, but when it crawls down into the roots to live it becomes very thick, and usually loses the colour rays. Dwarf shells, again, thick and strongly formed, are often found on exposed coasts where the surf beats strongly; and some *Littorina*, which are confined to more or less brackish water, have thicker shells where the water becomes less salt. In South Australia two races of *Littorina unifasciata* are said[1] to occur: the first, living on rocks, moist during the ebb-tide, is long, slender, and bluish-white; the second, living on dried and higher places, is short, with a light and dark grey chequered pattern. *Arca tetragona*, as found dwelling in old shells in the Channel Islands, is much swollen, but where it inhabits crevices of rocks, as in the south-west of England, it is compressed and the surface is worn.

In rivers Unionidæ have usually heavier shells than in lakes, and where the stream is turbulent the teeth are stronger and the muscular impressions deeper. Some species seem better able to form shell than others; for example, in the granitic parts of South-East Bavaria, *Unio*, *Neritina*, and *Lithoglyphus* have[2] thick shells, while *Ancylus*, which lives with them, has a very thin shell.

Land-shells living in decayed leaves are usually thin, a result which has been attributed to the difficulty of obtaining lime. This presence or absence of lime has an effect on the size of the shell, and molluscs have been seen gnawing not only one another's shells but even their own[3] in the endeavour to procure it.

Some molluscs have, naturally, flexuous shells, while in others this may occur abnormally, due, no doubt, to some failure in secretion.

Sexual dimorphism plays an important part in the size and shape of shells, notably in such forms as *Unio*, etc.

Temperature, again, must be considered, as, if it becomes too warm or too cold, the animal is much affected; several of the species found in thermal springs near Buda-Pesth were found[4] to be dwarfed.

We may mention, as one of a number of similar cases, the deformities of *Limnæa*, etc., noticed by Folin in the Lake of Ossegor, where the sea had broken in, abnormal surroundings, with the usual result of abnormal shells, following.

Gibbosity of the body-whorl is well known in *Limnæa* and *Planorbis*, and has been ascribed to periodicity in growth.

The variations of *Limnæa peregra* are said[5] to fall into natural groups, the long-spired being found in running water, the short-spired in lakes and ponds, while the strongly built forms dwell on the edges of large bodies of water or in turbulent streams, and those from hot or cold springs or great depths have generally a thin shell.

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[1] Haacke: Zool. Anz., vol. viii, p. 504.
[2] Clessin: Nachrbl. Deutsch. Malak. Ges., 1874, p. 87.
[3] Kobelt: Nachrbl. Deutsch. Malak. Ges., 1872, p. 44.
[4] Hazay: Mal. Blätt., ser. II, vol. iii, p. 7.
[5] Cf. Taylor: Journ. Conch., vol. vi, p. 284.

In confinement *Limnæa* is said[1] to vary in rate of growth, either with the nature of the water or the space the animals have in which to move; *L. megasoma* has been found to have narrower upper whorls in subsequent generations; the long and short spired races of *L. peregra* have been produced at will by changing the nature of the water; while it has even been asserted[2] that *L. involuta*, kept in confinement, has, in a few generations, lost its involute spire and become *L. peregra*.

Since the year 1767, when Geoffroy first noticed them, cases of remarkable distortion of the shell of *Planorbis* have been frequently recorded; sometimes isolated specimens were found, at others whole colonies appeared. Often other species occurring with them were found to be similarly distorted, but not invariably so. Similar variations have been observed in other species, but *Planorbis* has furnished the most striking instances and is here taken as a typical case. These forms exist in widely scattered localities, being described from England, France, Belgium, Germany, Switzerland, etc. This form of distortion is not confined to recent molluscs, a similar specimen of the Tertiary *Planorbis euomphalus*, J. Sby., having been observed. The appearance of these shells is very remarkable. They may be turreted, reversed, scalariform, and the direction of the whorl may vary from time to time. Piré[3] described and figured a long series of *Planorbis complanatus* from a pond in which he notes the presence of abundance of *Lemna* and *Conferva*. Van den Broeck[4] in discussing this paper suggested, and adduced experiments to prove, that scalariform shells moved more easily through the thick coating of weed than the normal ones; he further pointed out that being air-breathers they would desire to come to the surface, hinting also that we might be observing stages in the evolution or progress of *Planorbis*. Clessin, however, insisted[5] that these variations were separately formed and not transmitted.

Rufford,[6] noticing some abnormal specimens, found, on investigation, that in a number of them the worm *Chætogaster limnæi* was attached to the animal between the head and tentacles, and was inclined to attribute the results to its presence, though he very frankly stated that he had seen a normal specimen with a worm so attached.

Stubbs[7] illustrated a long series of forms of *Planorbis spirorbis*, and stated that the other species found in the same ditch near Tenby were also occasionally distorted or abnormal, and cites as a possible cause, quoting Taylor,[8] that the efforts to force their way through the mud in which they are sometimes left partially embedded, owing to

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[1] Semper: "Animal Life." Hazay: Mal. Blätt., ser. II, vol. iv, p. 220. Varigny: Journ. Anat. Physiol., vol. xxx, p. 147.

[2] More, Zoologist, 1889, p. 154; cf. Williams, t.c., p. 235.

[3] Ann. Soc. Mal. Belg., vol. vi, p. 23.

[4] Ibid., vol. vii, pp. x–xx.

[5] Mal. Blätt., vol. xx, p. 68.

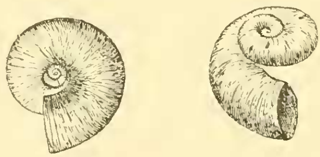
[6] Zoologist, 1898, pp. 191–192.

[7] Journ. Conch., vol. ix, pp. 106–108, pl. iv.

[8] Monogr. Brit. Moll., vol. i, p. 118; cf. Journ. Conch., vol. viii, pp. 382–384.

the fact of the ditch in hot weather nearly drying up, might cause alteration in the direction of shell, if it be in process of formation. This idea was hinted at by Jeffreys many years ago. Fortunately, however, Standen[1] made a careful examination of these forms, keeping them in an aquarium, and he found that all the distorted shells were covered with a luxuriant growth of *Epistylis anastatica*, one of the rigid-stalked *Vorticellæ*, whereas from the parts of the ditch lacking abnormalities the shells were clean and clear. This appears to be the probable cause, the animal shrinking when forming its shell from contact with the *Vorticellæ*.

While on the subject of these distorted forms I may recall a very interesting series of *Littorina rudis*, var. *tenebrosa*, noticed by myself,[2] from the Fleet Backwater near Weymouth. They were picked up, dead shells only being found, in quantity on the shore, and were perhaps killed by a cold spell which had occurred. I doubtfully referred then to the possible cause as being attached weed which the animal was endeavouring to avoid, and in the light of Standen's investigation further enquiry there seems very desirable.



Aulopoma, scalariform, from Ceylon.

Akin to these forms of *Planorbis* is the elevation or depression of the spire. *Helix pomatia*, for example, has been seen so depressed as to be planorbiform,[3] while the scalariform specimens are well known. Enquiry will probably show that this elevation or depression is correlated with some peculiarity of the animal. Baker[4] has recently observed, after taking measurements of a large number, that in *Pyramidula alternata* the western specimens have a higher shell than the eastern, and vary more in spire elevation. In the Island of Syra[5] it has been recorded that of *Pyramidula rupestris* more scalaroid than normal shells occur, and the theory has been put forward that, under some peculiar condition, a new race may be developing. Welch[6] has illustrated some interesting scalariform and distorted specimens of *Helix nemoralis* from the sand-dunes of Bundoran, and suggests that the distortion may be due to "the intrusion of a grain of sand during the early life of the mollusk, and the consequent deviation of the whorl from its normal course of growth." It is needless to go

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[1] Journ. Conch., vol. ix, p. 216.
[2] Proc. Dorset Club, vol. xiii (1892), pp. 191–198, one plate.
[3] Bellevoye: Bull. Soc. Rheims, vol. viii, p. 89.
[4] Amer. Nat., vol. xxxviii, p. 667.
[5] Nachrbl. Deutsch. Malak. Ges., 1880, p. 67.
[6] Journ. Conch., vol. x, p. 244.

through the list of genera or species in which scalariformity has been noticed, but it may be stated generally that, in most well-known land or fresh-water shells, it has been observed, while in marine shells it is less common. Indeed, all distortions are less common in marine shells, and where present they are chiefly recorded in those species living on the shore near high-water mark.

Mention may perhaps be made here of the remarkable specimen of *Bythinia tentaculata* recorded by Mr. Smith,[1] which had a very depressed spire and was almost 'Bulloid' in shape.

Sometimes the mollusc, after forming the lip in a normal manner, continues to grow and forms a second lip. This has been observed in *Helix*, *Clausilia*,[2] etc., while it should be remembered that a somewhat similar occurrence is usual in *Acroptychia*, *Leucoptychia*, etc. The suggestion has been made that a rainy season stimulated development and caused the growth to continue. Occasionally a second lip is formed in the mouth at an angle to the first, or irregular growth may continue after the mouth is formed.[3]

In *Clausilia* and *Cylindrella* specimens have been found with two apertures, sometimes at an angle to one another, sometimes back to back. Two explanations[4] have been given: either the shell may be fractured and the animal may make use of the fracture and form a new mouth, or it may be that some obstacle becomes wedged in the old mouth and the animal gnaws its way out in another spot, and forms the new mouth there.

Rissoa, again, has been observed[5] to form a new mouth if the old one be broken. Recently a specimen of *Helix pomatia* has been noticed with the mouth distorted and partly closed.[6] The curious addendum to the shell of an æstivating *Ancylus* noticed by Nordenskiold[7] hardly comes within my scope at the moment.

Limnæa, also, may be deformed by notches in the edge of the mouth, and in some specimens I examined I found that several, which at first sight were normal, had really been so notched, but that subsequently the animal recovered itself and filled up the notch by degrees. The occurrence has been attributed to *Hydra*.[8]

Beyrich[9] observed clefts in the columella of some species of recent and fossil *Natica*, and Martens[10] has recorded the same in *Buccinum*,

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[1] Journ. Conch., vol. v, p. 315.
[2] Westerlund: Nachrbl. Deutsch. Malak. Ges., 1875, p. 84. Clessin: Mal. Blätt., vol. xx, p. 58.
[3] Baudon: Journ. Conchyl., vol. xxxii, p. 320. Nelson: Journ. Conch., vol. xv, p. 80.
[4] Cf. Boettger: Nachrbl. Deutsch. Malak. Ges., vol. vi, p. 98. Gibbons: Quart. Journ. Conch., vol. i, p. 340.
[5] Dautzenberg: Feuille Nat., vol. xxiii, p. 30.
[6] Kobelt: Nachrbl. Deutsch. Malak. Ges., 1904, p. 125.
[7] Zool. Anz., vol. xxvi, p. 59.
[8] Cf. Brot: Ann. Soc. Mal. Belg., vol. xii, p. 48. Sykes: Journ. Malac., vol. iii, p. 34.
[9] S.B. Ges. Naturf. Berlin, 1883, pp. 3, 45.
[10] Ibid., 1889, p. 8.

and also in *Gibbula Richardi*, Payr., the latter author attributing the notches to the Cirripede *Alcippe*.

Buccinum undatum has been seen with a new canal formed at an angle to the old one,[1] and a specimen of *Fulgur canaliculatum* has been recorded by Johnson & Pilsbry[2] in which the basal canal was twisted to one side.

Pterocera varies occasionally in the number of labial digitations, Willey[3] noticing a specimen of *P. lambis* which has an extra intercalated digitation; this note is of some interest with reference to the origin of species, since he identifies this extra digitation with one of those of *P. millepeda*, L. Variation in the number has also been seen in *P. delicatula*, Nevill.

Again, the presence or absence of the umbilicus is not constant. There occurs in Mauritius and the Seychelles a race of *Achatina fulica*, Fér., in which the umbilicus is open. Mr. Pilsbry[4] states: "I am disposed to think the pathologic condition may be due to a disease of the left lobe of the mantle, possibly owing to some specific parasite of *A. fulica*."

Many species having spiral sculpture may be deprived of it by injury to the mantle; occasionally, again, species not normally carinate become so, the occurrence having been observed in *Helix, Placostylus, Limnæa, Buccinum, Rissoa*, etc.

The variation of *Cypræa* seems to deserve special notice. It will be a familiar fact to those who have studied the group, that there are found in New Caledonia,[5] mainly off the Island of Nou, deformations of most of the species belonging to that fauna; these forms are elongate, beaked, and generally marked by melanism. Their coral habitat or a malady of the animal have been suggested, but the matter is at present an unsolved mystery. *Cypræa* is also liable to be marked by obtuse spiral ridges on the back; or the spire, which normally in the adult shell is flat, may be produced so as to give the specimen the form of *Marginella*. Some specimens have been seen with a curious protuberance on the back; this is due to a *Balanus* having attached itself to the shell, the animal having then covered it with a deposit of shelly matter.

Of *Haliotis tuberculata*, L., three or four specimens have been recorded[6] in which the usual row of perforations is absent; and a specimen of *Haliotis Cracherodii* has been found, measuring nearly five inches in length, without any trace of perforations or indentations. On the other hand, Mr. Smith[7] has given an account of a specimen of *Haliotis*, now in the British Museum, which was furnished with two

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[1] Levett: Zoologist, ser. III, vol. viii, p. 490.
[2] Nautilus, vol. ix, p. 25.
[3] Proc. Linn. Soc. N.S. Wales, vol. xxi, p. 110.
[4] Man. Conch., ser. II, vol. xvii, p. 58.
[5] Cf. Dautzenberg: Journ. Conchyl., vol. li, p. 291.
[6] Jeffreys: Brit. Conch., vol. iii, p. 281. Smith: Conchologist, vol. ii, p. 75. Marquand: Journ. Conch., vol. xi, p. 48. Kelsey: Nautilus, vol. xviii, p. 67.
[7] Ann. Nat. Hist., ser. VI, vol. i, p. 419.

distinct rows of these perforations. He conjectured, as I understand it, that the edge of the mantle was notched either from birth or by accident; it seems to me that it may belong to a different category and may be due to duplication of the series of 'tentacles.'

The number of perforations is variable. In a series of *Haliotis tuberculata* sent from the Channel Islands, consisting of 97 specimens, all of 'merchantable' size, collected in February, I find the following variation:—

Number of completed holes ...	4	5	6	7	8
Number of specimens	3	25	50	17	2

If we still further subdivide them, allowing one-half for all holes which are well in progress of formation but not completed, we get—

Number of holes ...	4½	5	5½	6	6½	7	7½	8
Number of specimens	3	10	15	35	15	16	1	2

The result is of interest, though the series examined was small.

Pelecypods are liable to various deformations. Sometimes one valve is flattened, the other being inflated; again, a sinuation in the margin will occur, marked by a groove running towards the beaks, and this notch has been occasionally noticed to be present in one valve only. A curious specimen of *Modiolaria discors* that I have, has apparently had one end broken off, and has formed a new shell inside the old broken portion, lacking the characteristic sculpture, and with the edges not properly opposed. *Pecten* has been seen with a notched shell edge, this being due to the growth of Serpulæ. An abnormal outgrowth has been seen on the edge in *Mactra*,[1] and various deformations of *Anodonta* have been recorded, notably one in which the edges of the valves on the lower margin are folded inwards.[2]

As to the sculpture, *Cardium* is sometimes found with the margin duplicated, the effect being as if one shell were placed inside another; it has also been seen with the ribs dislocated, probably by a former damage.[3] The ribs in *Pecten* may divide late in life, or may arise then independently, and ridges may appear inside with no corresponding rib on the outside.

The internal colouring of the shell is liable to vary greatly, and *Anodonta* has been seen with the nacre of one valve white and the other of a salmon colour.

The hinge has been observed to be abnormal, and a case has been

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[1] Leidy: Proc. Ac. Philad., 1879, p. 198.
[2] Sci. Gossip, vol. xxiv, p. 127.
[3] Martens: S.B. Ges. Nat. Berlin, 1879, p. 74.

recorded in *Spatha* where the right valve overlapped the left.[1] The teeth in *Tapes* are liable to vary, one tooth being often aborted or lacking, and *Venus macrodon* has been noticed with only one tooth (not three) in one valve, and a corresponding cavity in the other.

One curious abnormality noticed[2] in the Polyplacophora is the reduction in number of the usual eight plates, either by suppression or union. Many years ago Montagu described a specimen as *Chiton septemvalvis*, and quite recently six-valved specimens of *Trachydermon ruber*, L., and *Ischnochiton conspicuus*, Cptr., have been noticed. Perhaps, however, the most remarkable is a three-valved specimen of *Ischnochiton contractus*, Rve., recorded by myself, in which the tail-valve occupied a greater space than the other two valves put together, being probably formed by union of two or more valves. This specimen is now preserved in alcohol in the British Museum.

Amongst Cephalopods we may refer to the interesting specimen of *Argonauta* recently figured[3] in our *Proceedings*, which had a double sinuation on the left side; as also to that recorded by Adams,[4] which had a portion broken out of the left side. He pointed out that this was repaired in the usual manner, but that the fragment which had been broken out, its loss having probably been prevented by the vela, now formed two-thirds of the repaired portion, while it had actually been reversed in position, the inside having become the outside.

One of the most interesting phenomena, perhaps, is when the coil of the shell in the Gastropods is reversed, accompanied by a corresponding deformation in the animal, or when a similar occurrence takes place in the Pelecypods. As is well known, the majority of the Gastropods have dextral shells, but a fair proportion are normally sinistral. In some groups the bulk of the known forms are constantly sinistral as in the Clausiliidæ, whilst in such as the Helicidæ a few species only have this character, or it may happen that certain sections of a family are reversed. In other groups, again, such as *Amphidromus*, *Partula*, and *Achatinella*, some of the species are normally found in both conditions; the proportion, however, of each kind will vary in each species, and it has been stated that *Partula otaheitana*, Brug., is generally reversed, while *P. vexillum*, Pease, has only one in fifty, and *P. affinis*, Pease, only one in several hundred sinistral. *Dyakia Lindstedti* is another illustration of the principle that a species may be normally both sinistral and dextral. We may also recall the well-known case of *Sipho antiquus*, of which a colony of sinistral specimens were found in Vigo Bay.

Whether these forms be in a strict sense hereditary, it is hard to say; in my view the cause that rendered the parent reversed may well, acting in conjunction with a predisposition to abnormality, give a greater probability of reversal in the descendants. Nylander has

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[1] Jickeli: Nachrbl. Deutsch. Malak. Ges., vol. v, p. 69.
[2] Cf. Sykes: Journ. Malac., vol. vii, p. 164. Stearns: Nautilus, vol. xv, p. 53. Blaney: Proc. Boston Soc., vol. xxxii, p. 39.
[3] *Ante*, vol. v, p. 310.
[4] Amer. Journ. Sci., vol. vi, p. 138, 1848.

recorded the occurrence of four young sinistral shells from a normal dextral female of *Campeloma decisa*, Say; whilst Miss Hele noted the occurrence of dextral young from a sinistral *Helix aspersa*. On the other hand, sinistral *Limnæa stagnalis* have been bred from a sinistral parent, and in a pond in Belgium adult sinistral specimens of this species were found in one year, whilst in the following year similar young shells were taken, this leading to the suggestion that these latter were descendants of the former. I think the evidence amounts to this, that a sinistral parent shell is not unlikely to have sinistral young, but this result may not follow. It may be remarked, in passing, that in *Melantho* 15–25 per 1000 of the embryos are sinistral, but only 1 per 1000 survives. In slugs[1] *Limax schwabii*, Frauenfeld, has been recorded with the respiratory opening on the left side, and *Arion rufus*, L., with a similar character.

It may perhaps be of interest to give a list of the shells which I know of recorded as reversed. It is not proposed to deal with the vexed question of ultra-sinistral and ultra-dextral shells, and for the purpose of the moment *Planorbis* has been left as dextral. Owing to the scattered nature of the literature this list must be very incomplete, but may form a basis for other workers: no attempt has been made to verify the specific names.

Sinistral Forms of normally Dextral Species.

* All so marked have been seen by the writer.

Gibbus Lyonetianus, Pallas.
Vitrina pellucida, Müller.
Hyalinia nitida, Müller.
,, *nitidula*, Drap.
Zonites Algirus, L.
Xesta duplocincta, Bttg.
* ,, *Javanica*, Fér.
Laoma Moellendorffi, Suter.
**Pyramidula alternata*, Say.
,, *Cooperi*, Binn.
,, *humilis*, Hutton.
,, *rotundata*, Müll.
,, *solitaria*, Say.
,, *strigosa*, var.
Polygyra elevata, Say.
,, *exoleta*, Binn.
,, *fallax*, Say.
,, *hirsuta*, Say.
,, *inflecta*, Say.
,, *Mitchelliana*, Lea.
,, *profunda*, Say.
,, *thyroides*, Say.
Pleurodonte lychnuchus, Müll.
Stylodonta unidentata, Chemn.
**Acavus hæmastoma*, L.
* ,, *phœnix*, Pfr.
**Dorcasia globulus*, Müll.
,, *lucana*, Müll.
**Leucochroa candidissima*, Drap.
Helicella acuta, Müll.
,, *apicina*, Lam.
* ,, *Cantiana*, Mont.
,, *Carthusiana*, Müll.
,, *cespitum*, Drap.
,, *conspurcata*, Drap.
* ,, *cricetorum*, Müll.
,, *explanata*, Müll.
,, *fasciolata*, Moq.
,, *neglecta*, Drap.
,, *oreta*, Brgt.
,, *trepidula*, Serv.
,, *trochoides*, Poiret.
,, *unifasciata*, Poiret.
,, *variabilis*, Drap.
* ,, *virgata*, Da Costa.
Hygromia hispida, L.
,, *limbata*, Drap.
Vallonia pulchella, Müll.
**Helicigona arbustorum*, L.
,, *cornea*, Drap.
,, *lapicida*, L.
,, *Quimperiana*, Fér.
**Helix apalolena*, Brgt.
,, *aperta*, Born.
* ,, *aspersa*, L.
* ,, *hortensis*, Müll.

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[1] Cf. Baudon: Journ. Conchyl., vol. xxxii, p. 320. Seibert: Mal. Blätt., vol. xxi, p. 198.

* *Helix lactea*, Müll.
* ,, *nemoralis*, L.
* ,, *Pisana*, Müll.
* ,, *platychela*, Menke.
* ,, *pomatia*, L.
* ,, *punctata*, Müll.
,, *splendida*, Drap.
,, *sylvatica*, Drap.
,, *vermiculata*, Müll.
**Placostylus Æsopus*, Gass.
* ,, *fibratus*, Mart.
,, *senilis*, Gass
,, *Ouveanus*, Mouss.
Orthalicus regina, Fér.
,, *undatus*, Brug.
Rumina decollata, L.
Ena detrita, Müll.
Pupa avenacea, Brug.
,, *Bigorriensis*, Charp.
,, *Brauni*, Rossm.
,, *muscorum*, L.
Achatina panthera, Fér.
,, *virginea*, Brug.
Cochlicopa tridens, Pult.
Cionella lubrica, Müll.
**Succinea elegans*, Risso.
* ,, *Pfeifferi*, Rossm.
Limnæa limosa, L.
,, *ovata*, Drap.
,, *palustris*, Drap.
* ,, *peregra*, Müll.
* ,, *stagnalis*, L.
Planorbis complanatus, L.
,, *spirorbis*, L.
Campeloma decisa, Say.
Valvata piscinalis, Müll.
Vivipara vivipara, L.
* ,, sp. indet. [in B.M., juv., from China].
Neritina fluviatilis, L.
Ericia elegans, Müll.
**Pomatias crassilabrum*, Drap.
,, *obscurum*, Drap.
,, *patulum*, Drap.
* ,, *septemspirale*, Raz.
Ditropis planorbis, Blanf.
**Diplommatina catathymia*, Sykes.
**Acme lineata*, Drap.
**Voluta scapha*, Gmel.
**Marginella conoidalis*, Kien.
* ,, *curta*, Sby.
* ,, *limbata*, Lam.
,, *miliacea*, Val.
,, *nebulosa*.
* ,, sp. indet. [group of *avena*, Val.].
**Murex secundus*, Lam.
,, *trunculus*, L.
**Buccinum undatum*, L.
Purpura lapillus, L.
**Sipho antiquus*, L.
**Turbinella rapa*, Gmel.
**Littorina litorea*, L.
* ,, *rudis*, Maton.
**Olivella oryza*, Lam. [Brit. Mus.].

Dextral Forms of normally Sinistral Species.

Ena quadridens, Müll.
Clausilia Almissana, Küster.
,, *bidens*, Drap.
,, *bidentata*, Ström.
,, *biplicata*, Mont.
,, *Duboisi*, Charp.
,, *Macarana*, Zgl.
Clausilia perversa [? L. or Pfr.].
,, *plicata*, Drap.
* ,, *plicatula*, Drap.
,, *Stentzi*, Rossm.
Pupa perversa [? author].
Physa fontinalis, L.

Amongst the Pelecypods a similar occurrence has been observed. *Chama* is said to be frequently reversed, and a reversed *Tellina plicata*, with the hinder fold of the shell bent to the left, has been recorded by Fischer.[1] Jeffreys states that *Astarte compressa* and *A. triangularis* sometimes have the hinge reversed, i.e., the right teeth being in the left valve, and *vice versa*.

The question naturally arises, what is the cause of this curious inversion? Dealing only with the Gastropoda two points are clear; firstly, that it must arise from a cause common to a very large number of species, and, secondly, that the cause takes effect in the early stages of development, ere the protoconch is formed. One explanation suggested has been the effect of the presence of abundant electricity in the air; another writer, stating that sinistral and dextral forms of

[1] Journ. Conchyl., vol. xxviii, p. 234.

a species of *Partula* are isolated from one another, has hinted at the effect of environment. Again, we have been told that "this abnormal growth probably is caused by disturbance of the relations of the embryo with its initial shell." Hartman,[1] when dealing with *Partula*, says as follows: "We can only conjecture as to the cause of this departure from the more usual conformation; but it may be owing to a reversal of the vital forces acting during the segmentation of the yolk of the egg in the early stages of the formation of the embryo. The eggs of the common garden slug (which are almost transparent and afford good material for observation), a short time after deposition, exhibit the germinal vesicle (which lies in the midst of the yolk) rising to the upper part, where a distinct rotation may be seen; after which it undergoes segmentation, and the germ appears. The rotary motion, which is probably due to ciliary or vital action, consists of two or three turns in one direction, and the same number in a reversed one; and in this reversed vital action, during segmentation of the yolk of the egg, may be the secret of sinistral or reversed shells."

Let us now turn to recent research in biology. In 1894 Crampton and Kofoid pointed out that in sinistral snails the cleavage of the egg from the second division onwards is typically spiral but reversed. Conklin, to whose papers[2] I am indebted for the facts here given, later found that in *Crepidula* this spiral character commenced with the first division of the egg; and in 1903 he summed up the matter of inverse symmetry, stating that, in such cases, the cleavage is inverse and must be preceded by inverse organization of the unsegmented egg, probably arising at the time of maturation or fertilization. Further, he suggests that there may be a reversal of polarity after the eggs are set free, which may perhaps be due to pressure on the egg-cell forcing the spindle through the egg and causing the polar bodies to be formed at the opposite pole to that which is usually the case.

Space fails me to give any details of Weldon's work from the statistical standpoint and to refer to other details, but I have now given some outline, brief and imperfect though it be, of variation in molluscs, and I would conclude by appealing to you to give your most serious attention to the subject, that the malacologist may bear his full share of the work, and receive his full share of the credit, in the solution of the many problems to which it is the key.

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[1] Bull. Mus. Comp. Zool., vol. ix, pp. 176–177.

[2] Journ. Morphol., vol. xiii, pp. 1–226; Anat. Anz., vol. xxiii, pp. 577–588; Proc. Ac. Philad., 1903, p. 753.